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## HARD CLOVER SEED AND ITS TREATMENT IN HULLING.

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### INTRODUCTION.

The seeds of many species of the clover family are frequently incapable of readily taking up the water necessary for their germination. The reason for this incapacity is that the seed coats of such seeds are completely waterproof—at least for a time.

Seeds having such impervious seed coats are known as hard-coated or simply as hard seeds.

### OCCURRENCE AND SIGNIFICANCE OF HARD CLOVER SEEDS.

The occurrence of varying proportions of hard seeds in commercial lots of the different clovers has long been recognized. The question of the agricultural value of these hard clover seeds has been much discussed. Nearly all such seeds will lie in water or in wet cloths for many months without change, and frequently many of them will remain unchanged after several years in water. As soon, however, as the waterproof seed coat is broken or becomes permeable to water the seed takes up water rapidly and usually germinates, producing a strong, healthy seedling. It is of importance to the farmer who sows clover seed that germination should occur promptly instead of after a delay of indefinite duration, pending a change in the seed coat. Herein lies the greater value of clover seed which is not hard; that is to say, which is not impervious to water. Hard clover seed, especially hard sweet-clover seed, may under certain conditions be of value. If sowed early in the spring or late in the fall, so that it lies in the ground during freezing weather preceding the first growing season, much of it will germinate. Again, hard seeds remaining in the soil will, after the first winter, help to improve a clover stand which is poor in spots. For ordinary seeding purposes good clover seed which is not hard is always preferable.

NOTE.—The facts brought out in this bulletin are of special interest to farmers who grow clover for the seed, to farmers who sow clover seed, to seedsmen, and to the manufacturers and operators of clover-hulling machinery.

**THE HARDNESS OF COMMERCIAL CLOVER SEED COMPARED WITH THAT GATHERED AND CLEANED BY HAND.**

The percentage of hard clover seeds in commercial lots of red clover, alsike clover, and white clover usually is comparatively small. In commercial lots of sweet-clover seed the proportion varies from less than 10 per cent in some lots to more than 90 per cent in others. The writer, however, has found a very large percentage of hard seeds in hand-harvested and hand-hulled lots of each of these four kinds of clover. The present bulletin reports the results of investigations to discover the reason for this difference between commercial clover seed and clover seed gathered, hulled, and cleaned by hand, and also the relation of certain other factors to the character and size of the clover-seed crop.

**THE HARDNESS OF CLOVER SEED NOT A VARIETAL CHARACTERISTIC.**

It was at first thought that extreme hardness of seed might be a hereditary characteristic of varieties or strains of the different clovers in contrast to others which possessed no such tendency. That this is not the case is proved by the results of trials upon the experimental plats of the Seed Laboratory during the past six years (1909 to 1914, inclusive). All of the seed harvested from these plats has been gathered in small lots and hulled by hand. Each lot of this hand-hulled seed has contained a large percentage of hard seeds. The percentage has been as great in lots grown from seed only one-twentieth of which was hard as in lots from seed nineteen-twentieths of which was hard.

**THE HARDNESS OF CLOVER SEED INDEPENDENT OF SOIL, SEASONAL, AND CLIMATIC CONDITIONS.****SOIL.**

Red-clover seed, alsike-clover seed, white-clover seed, and white sweet-clover seed have been grown on heavy clay soil and on light sandy soil with the same degree of hardness in the resulting crop of hand-hulled seed. Seed gathered from wild wayside plants has been very hard also.

**SEASON.**

Samples of well-matured clover seed of one or more of the four kinds named in the preceding paragraph have been harvested and hulled by hand each season for the last six years. Each of these samples has contained a large proportion of hard seeds. Furthermore, if the seed is equally well matured it makes no difference whether it is harvested early from the first growth of the plants or later from the second growth, the first growth being cut green.

**CLIMATE.**

Samples of seed grown from the same original lots near Washington, D. C., at Burlington, Vt., at Madison, Wis., at Corvallis, Oreg., at Columbus, Mo., at Wooster, Ohio, and at Yuma, Ariz., and harvested and hulled by hand, have all contained a large proportion of hard seeds.

**THE HARDNESS OF RED-CLOVER SEED INDEPENDENT OF ITS COLOR AND SIZE, PROVIDED THE DEGREE OF MATURITY AND METHOD OF HANDLING ARE THE SAME.****COLOR.**

In one lot of hand-hulled red-clover seed 88 out of every 100 seeds were pure yellow. In another lot 83 out of every 100 seeds were dark purple. Each of these two lots had 83 per cent of hard seeds. The average percentage of hard seeds in 12 lots of predominantly light-colored seed was 89; the average in 16 lots of predominantly dark-colored seed was 88.

**SIZE.**

One lot of hand-hulled red-clover seed which weighed 990 milligrams per thousand seeds and another lot which weighed 1,949 milligrams per thousand seeds had, respectively, 84 per cent and 82 per cent of hard seeds. In a large number of other weighed lots the proportion of hard seeds was wholly independent of the size of the seeds.

**THE EFFECT OF HARVESTING AND HULLING OPERATIONS ON CLOVER SEED.**

During September, 1914, the writer visited the Fond du Lac clover-seed region of Wisconsin and procured a large number of samples of red-clover heads taken from standing clover and from clover in the windrow, cock, mow, and stack, as well as samples of seed taken immediately after it left the hulling machine. A smaller number of samples was procured of alsike clover, white clover, and white sweet clover, both hulled and in the heads. Additional samples were obtained from farmers and from operators of hulling machines as the clover hulling advanced.

The seeds from these samples of clover heads, procured as stated in the preceding paragraph, were rubbed out from the hulls by hand. Both these lots and other lots of seed which were hulled by machine were subjected to germination tests in the Seed Laboratory.

The data obtained in testing the various samples, the results of the germination tests, and the results of physical examinations of some of the samples show the effect of the various methods of curing and storing the unhulled clover and the effect of the hulling operation upon the hardness and other characteristics of the seed.

**THE EFFECT OF MACHINE HULLING UPON THE GERMINATION AND HARDNESS OF CLOVER SEED.**

In making the germination tests 200 well-developed, bright-looking seeds of each lot were used. A few seeds softened but did not germinate. These were excluded from the computed results of the germination tests. In this way immature seeds, seeds injured by unfavorable conditions either before or after cutting the clover, seeds infested by the chalcis fly, and a few seeds badly broken by the hulling machine were eliminated. The result of each test shows, therefore, for each 100 viable seeds how many germinated and how many remained hard at the end of the germination test.

In a little more than half the cases the machine-hulled samples and those hulled by hand were taken from clover which was grown in the same fields.

Table I shows the average number of hard seeds per hundred seeds in the hand-hulled and in the machine-hulled samples of each kind and the number of samples from the germination tests of which each average is derived.

TABLE I.—*Average number of hard seeds per hundred in hand-hulled and in machine-hulled lots of clover seed.*

Kind of seed and number of samples.	Manner of hulling.	Average number of hard seeds per 100.	Kind of seed and number of samples.	Manner of hulling.	Average number of hard seeds per 100.
Red clover: 299 samples.....	By hand.....	92	White clover: 9 samples.....	By hand.....	98
208 samples.....	By machine...	17	5 samples.....	By machine...	34
Alsike clover: 21 samples.....	By hand.....	90	White sweet clover: 6 samples.....	By hand.....	98
36 samples.....	By machine...	18	1 sample.....	By machine...	20

Of each 100 hand-hulled seeds of each kind 90 or more were hard. This indicates that in the natural condition nine-tenths or more of the fresh, well-matured seeds of these kinds of clover are hard coated.

Only 17 of each 100 machine-hulled red-clover seeds, 18 of each 100 machine-hulled alsike-clover seeds, 34 of each 100 machine-hulled white-clover seeds, and 20 of each 100 machine-hulled white sweet-clover seeds were hard. Evidently a great decrease in the proportion of hard seeds is caused by hulling them in a clover huller. In other words, of every 100 pounds of clover seed about 90 pounds go into the huller as hard-coated seeds of uncertain value, and of these 90 pounds 60 or 70 pounds leave the huller as valuable seeds capable of prompt germination and vigorous growth.

#### THE HULLING CYLINDER AND ITS EFFECT ON THE HARDNESS OF CLOVER SEED.

After the clover heads are removed from the straw by the thrashing cylinder of the hulling machine they are passed over another larger cylinder, where the seeds are hulled. This hulling cylinder is completely covered with a coarse steel rasp and revolves within a concave which is covered with the same material. The concave is usually set so that there is just room for the seeds to pass between it and the cylinder. The severe rubbing, with the pressing which the seeds undergo in passing between the hulling cylinder and the concave, not only removes the hulls but so alters most of the seed coats that they become capable of admitting water. Nearly all the seeds show no visible indication of this change, but frequently a few seeds out of every hundred are noticeably broken. Some of these broken seeds are not injured except in their power to retain their vitality for a long period of time. Others are broken in such a manner as to make them valueless.

**THE COMPARATIVE HARDNESS OF RED-CLOVER AND ALSIKE-CLOVER SEED HULLED BY DIFFERENT MACHINES.**

Samples of hulled clover seed were received during the clover-hulling season from six different operators of clover hullers.

The samples sent by each operator were hulled from clover grown on a number of somewhat widely separated farms. Comparative examinations of these samples show considerable difference in the condition of the seeds hulled by the various machines.

Table II shows the average number of hard seeds per hundred in the samples of machine-hulled red clover and alsike clover received from each huller operator.

TABLE II.—*Average number of hard seeds per hundred in samples of red-clover and alsike-clover seed hulled by different machines.*

Machine.	Red clover.		Alsike clover.		Machine.	Red clover.		Alsike clover.	
	Number of samples.	Average number of hard seeds per 100.	Number of samples.	Average number of hard seeds per 100.		Number of samples.	Average number of hard seeds per 100.	Number of samples.	Average number of hard seeds per 100.
No. 1.....	38	10	5	10	No. 4.....	38	14	2	20
No. 2.....	17	11	.....	.....	No. 5.....	16	22	8	20
No. 3.....	25	13	3	10	No. 6.....	28	36	1	37

In samples both of red clover and of alsike clover hulled by machine No. 1 an average of 10 seeds per 100 were hard. In samples hulled by machine No. 6 an average of 36 red-clover seeds per 100 and 37 alsike-clover seeds per 100 were hard. The samples hulled by the other machines were intermediate in their proportion of hard seeds between the samples hulled by these two machines.

**CLOVER HULLERS AS SCRATCHING MACHINES.**

A number of machines have been devised at different times for the purpose of scratching or abrading hard seeds so that they will germinate readily. The possible effectiveness of the clover huller in bringing about this result has never been seriously considered. The results of this investigation as given in the preceding pages show that the clover huller in practice alters a large proportion of the hard seeds so that they will germinate promptly. In fact, the proportion of hard seeds in a sample of clover seed seems to express inversely the effectiveness of the huller as a scratching machine at the time when the sample under consideration was hulled. It is a question of great interest whether the construction or operation of the types of hulling machines now in use could be so modified as to leave "hard" none of the seeds which they hull.

Of the hulling machines mentioned in Table II, No. 6 was of one make and the other five of another make, differing somewhat in detail, though of the same general type. The differences in the proportion of hard seeds in samples hulled by the various machines were practically constant through the hulling season. Possibly differences in

the construction of the two kinds of machines cause the higher proportion of hard seeds in samples hulled by machine No. 6. On the other hand, the differences between the samples hulled by the other five machines, which were all of one kind, indicate that the method of operating the huller influences the proportion of hard seeds in the hulled product.

#### **SEEDS BROKEN OR MARKED IN THE HULLING MACHINE.**

As previously stated, a few seeds were broken by the hulling machine. Twenty-five bright, well-matured seeds of each of a number of samples of machine-hulled red-clover seed, 50 seeds of one sample of machine-hulled alsike clover, and 50 seeds of one sample of machine-hulled white clover were examined for the presence of such seeds. All seeds with breaks in the seed coats sufficient to be seen with a binocular magnification of 28 diameters were removed. The remaining seeds and a like number of seeds from the corresponding hand-hulled samples were then submitted to four different seed-testing experts, each of whom was totally unable, even with the help of a binocular microscope, to determine by the appearance of the seeds which samples were hulled by hand and which by machine. Since comparatively few seeds in the machine-hulled samples were broken and the remainder were nearly all capable of germination, it follows that the effect of the hulling machine on nearly all of the seeds was produced without leaving any visible evidence in their appearance.

#### **THE NUMBER OF SEEDS BROKEN BY DIFFERENT MACHINES AND THE CHARACTER OF THE BREAKS.**

Ten samples of red clover hulled by machine No. 1 and 10 samples of red clover hulled by machine No. 6 were selected for comparison. Fifty bright, well-matured seeds of each sample were examined for the presence of broken seeds or broken seed coats, using binocular lenses which magnified 65 diameters. Breaks were found in an average of about 1 seed in 50 in the samples hulled by machine No. 6, and in an average of about 1 seed in 6 in the samples hulled by machine No. 1. All of the breaks in the seeds hulled by machine No. 6 and a part of the breaks in the seeds hulled by machine No. 1 were minute cracks in the seed coats. However, a few of the seeds hulled by machine No. 1 were so broken as to destroy the embryo; in still others large pieces of the seed coat were broken away, exposing a part of the embryo. This breaking of the seeds should be avoided as far as possible. The problem of the adjustment and operation of the huller seems, then, aside from the mere hulling and cleaning of the seeds, to be a matter of the maximum reduction of the hardness of the seeds with a minimum amount of breaking of the seeds.

#### **THE EFFECT OF ROTTING THE CLOVER IN FIELD OR STACK UPON THE QUALITY AND YIELD OF CLOVER SEED.**

Many farmers allow their clover to rot for several weeks after cutting before they stack it or draw it to the barn.

Sometimes red clover cut early is allowed to lie in the swaths or windrows for two months, or even longer, exposed to all kinds of

weather conditions. Frequently, also, clover stacks, if poorly constructed or unprotected, become wet and musty. Sometimes in wet portions of the stack the clover straw will even become very black and largely decomposed before the seed is hulled. The effect of such exposure in field or stack is to cause the swelling and sometimes the germination of seeds which are not protected by hard seed coats.

Even if they do not germinate, seeds which have been thoroughly swollen for some time and subsequently dried are of no value. They are brown, frequently wrinkled, with a lusterless appearance and rough texture of the seed coat, and they possess very low vitality, if they are not actually dead. If the seeds are not thoroughly dry in the heads when cut and the cut clover is rained upon before it has had time to dry, a great many seeds may be destroyed in this manner. The damage may become still greater if portions of a stack heat and become very warm as well as wet.

In a locality where frequent rains occur during the clover-ripening season some seeds will germinate and others will become brown and dead even before the clover is cut. The proportion thus affected before the clover is cut is small.

The proportion of dead or germinated seeds in the hulled product increases according to the exposure of the clover previous to hulling. For example, (1) 169 small samples of red clover were gathered in the heads, hulled by hand, and examined for the presence of germinated seeds. One sample in every 15 gathered from standing clover, 1 sample in every 7 gathered from cut clover which showed no evidence of unusual exposure, 2 samples in every 5 from the dry outsides of stacks and from mows in the barn, 3 samples in every 5 from the very wet and sometimes rotten undersides of cocks or windrows, where they had lain for weeks, and 3 samples in every 5 from wet, decayed portions of unprotected stacks contained germinated seeds. (2) A number of samples were carefully examined for the proportion of dead and germinated seeds. The average proportion of dead or germinated seeds in 17 samples of red-clover seed gathered from standing clover was 1 seed in every 25. The average proportion in 13 samples taken from the dry tops of windrows or cocks also was 1 seed in every 25, but the average proportion in 13 other samples taken from the wet, sometimes moldy or decaying bottoms of the same windrows and cocks was 1 seed in every 12. (3) The average proportion of dead or germinated seeds in 4 samples taken from the dry outsides of stacks was 1 seed in every 16; the average proportion in 4 other samples taken from wet and decomposing areas in the interior of the same stacks was 1 seed in every 4.

It is impossible to estimate the loss occasioned by unfavorable weather conditions while the clover lies upon the ground or is stored in stacks, but it must in some cases be considerable.

#### **ROTTING OR SWEATING CLOVER BEFORE HULLING UNNECESSARY.**

The writer saw one owner and operator of a clover huller hulling clover from two different fields on his own farm. The clover from one field had been cut for several weeks, during the most of which time it had lain in windrows. The seed which it yielded was inferior

in grade, by reason of the dead, brown seeds which it contained. These could probably be removed satisfactorily, but the yield would be lessened by removing them. The clover from the other field was cut three or four days before the hulling of it commenced. It was well cured; it seemed to hull about as easily as the clover from the first field, and it yielded a product practically free from dead, brown seeds. Some other farmers in the vicinity also hulled their clover from the field as soon after cutting as it was thoroughly dry, and still others cured their clover rapidly, as if for hay, and stored it previous to hulling, either in the barn or in well-covered stacks.

The best practice would seem to be to allow the clover to become as ripe as possible without loss from shelling, cut it in good, bright weather, and then protect it from exposure to rains. If a huller can be procured at once, hulling direct from the field will economize labor. If it is necessary to delay the hulling, damage and loss to the seed crop will be avoided by storing the clover in a barn or in a carefully constructed and well-covered stack.

#### SUMMARY.

By hard seeds is meant seeds whose seed coats are impervious to water. While such seeds remain hard, they are unable to absorb the water necessary for their germination.

In nature, nine-tenths or more of the well-matured seeds of red clover, alsike clover, white clover, and white sweet clover are hard. Hard clover seeds are sometimes of value, but are usually much inferior to good seeds which are not hard.

The hardness of well-matured clover seed is not influenced materially by conditions of soil, by seasonal variations, by climatic conditions, or by the time at which the seed is harvested.

The hardness of well-matured red-clover seed is not related to its color or size.

The rotting of clover in field or stack kills some of the seeds and may reduce the quality of the hulled crop, but it does not affect the proportion of hard seeds in the hulled crop after the dead seeds are removed.

The rotting of the clover in field or stack or sweating it in the mow before hulling is not necessary. To secure the greatest yield and highest quality of seed the clover should be cured and stored with as little wetting as possible.

The rubbing which clover seed receives in the hulling machine greatly reduces the proportion of hard seeds, but frequently breaks some of the seeds.

The clover-seed huller is, therefore, an effective scratching machine. The aim should be to have the huller so constructed and so operated as to reduce the proportion of hard seeds to the greatest possible extent and at the same time to break the smallest possible number of seeds.